61.354

No. 736,288



June 14, 1966

CLASS 166-16

GROUP

CLASSIFICATION

## CANADIAN PATENT

LINER EXPANDER

Joe C. Stall, Tulsa, Oklahoma, U.S.A.

Granted to Pan American Petroleum Corporation, Tulsa, Oklahoma, U.S.A.

APPLICATION No. 897, 460

FILED

PRIORITY DATE

No. OF CLAIMS

#### LINER EXPANDER

10

20

30

This invention relates to a constant force spring device, and more particularly, to a device for expanding a metallic liner wherein an expanding die is urged against the liner by a constant force spring device.

Heretofore, a method and apparatus have been developed for installing an expanded metallic liner in an oil well or other conduit. Typically, a corrugated steel liner is inserted in a conduit which is to be lined, the greatest peripheral dimension of the liner being slightly less than the inside diameter of the conduit. An expanding tool is passed through the liner placed in the conduit, and a first-stage expanding die causes a gross plastic deformation of the liner, which is expanded outwardly against the inside of the conduit. A second-stage die on the tool then provides an additional finer deformation of the liner to provide a smoother, more finished surface on the inside of the liner and to assure more complete contact between the conduit and the liner. In a typical design of this type expanding tool, the frictional drag of the first-stage die supplies the expanding force for the second-stage die, which expanding force is a direct function of the strength, or wall thickness, of the conduit in which the liner is being installed. For example, in lining oil well casing, heavy wall casing may cause a very high frictional force which results in excessive pressure being required to push the expander through the liner. The application of the great forces required may result in rupture of the casing or in breaking the installing tool. In instances where the internal diameter of the conduit is somewhat less than that anticipated, the resulting forces can cause the tool to become stuck in the casing, or otherwise cause damage to the casing and the tool. In other designs, such as where a cantilever spring arrangement is employed in connection with the secondstage die, various difficulties are encountered in obtaining a spring mechanism having the desired strength in combination with the other spring characteristics, and with the tool dragging against the inside wall of the conduit after being passed through the liner.

1 -

\*

Since tools of the type mentioned above often are employed in wells deep in the ground, it is highly preferable that a tool be used which under no circumstances will become stuck in the well or cause damage to the well. Any such trouble occurring in a well can result in considerable loss in time and great expense in making repairs.

An object of the present invention is a device for applying a constant force to an expanding die or other similar apparatus so that a preselected maximum force is exerted against a work piece. Another object is an improved expanding tool for installing metallic liners in a conduit, which expanding tool can apply no greater than a predetermined force to the liner being installed in the conduit. Still another object of the invention is an economical and easily fabricated constant force spring device. A further object is a rugged, easy-to-operate expanding tool employing such a spring device. These and other objects of the invention will become apparent by reference to the following description of the invention.

In accordance with the present invention there is provided a constant force spring device which comprises a body member, an elongated column element adjacent said body member, bearing plate members contacting the two ends of said column at least one of said bearing plate members being longitudinally movable in respect of the other and stop means on said body member to limit the deflection of said column element to prevent permanent deformation of said column element upon the application of a compressive load thereto. In one embodiment of the invention, the foregoing constant force spring device is employed in a tool for expanding a metallic liner inside a conduit, said constant force spring device being positioned on said tool to urge an expanding die member against the liner being installed in the conduit by a substantially constant force.

My invention will be better understood by reference to the following description and the accompanying drawings wherein:

Figures 1A, 1B and 1C, taken together, constitute a partial sectional view of a preferred embodiment of a liner expanding tool according to the present invention; and

30

Figure 2 is a sectional view of the apparatus of Figure 1A taken at line 2-2; and

Figure 3 is a typical plot of applied Load versus Deflection for the constant force spring device of the invention.

Referring to the drawings, Figure 1A is the bottom portion of a liner expanding tool for use in installing a metallic liner in a well, while Figure 1B illustrates the middle section of such a tool and Figure 1C represents the upper section of the tool. The expanding tool 11 is attached to standard well tubing 12 by coupling 13 and, typically, may be lowered from the surface through a well casing (not shown) to a point in the casing at which it is desired to install a metallic liner. Before inserting the tool into the well, an elongated vertically corrugated liner 14 fabricated from mild steel, or other suitable malleable material, is placed on the tool. The corrugated liner is secured in position by contact at its upper end with a cylindrical shoulder member 16 and, at its lower end by contact with a first-stage expanding die 17 in the form of a truncated circular cone which serves as a firststage expanding die in the manner hereinafter described. The expanding die is fixedly attached to a centrally located, elongated cylindrical hollow shaft 18 which forms a portion of the body of the tool. As shown, the expanding die 17 is held in place between a lower shoulder 19 and collar 21 threaded onto the shaft. A plurality of movable arms 22, preferably provided with outwardly enlarged portions 23 near the top, are disposed in the form of a cylinder around shaft 18. The enlarged portions of the arms 23 upon being moved outwardly contact the liner to perform the final step of expanding the corrugated liner into a substantially cylindrical shape. The arm members 22 are pivotally attached to the shaft so as to be movable outwardly from the shaft by a tapered expanding member 24 slidably positioned on the shaft to serve as a second-stage expander. The surface of the member 24, as shown, moves upwardly along the shaft to engage with the arms and move them outwardly. Advantageously, the inside surfaces of the arms 22 and the outside surface of expanding member 24 form mating sections, typically octagonal in shape. The expansion of the arm members is controlled by the position of the member 24 which moves upwardly

20

30

 $\mathbf{a}$ 

until it contacts shoulder 26 provided on the shaft. As member 24 moves in a downwardly direction arms 22 fold inverdly toward the shaft. The expanding arms 22 are held in place on the shaft by collar 27 and circular groove 28 provided on the shaft.

The expanding tool, comprising the first-stage die and the secondstage die is drawn through the liner to expand it in place in the casing. The
first-stage die provides a gross deformation of the liner so that it is
expanded outwardly against the wall of the casing. The second-stage die then
passes through the liner and performs the final expansion to smooth the inner
surface of the liner and to provide more even contact between the liner and
the wall of the casing and effect a fluid-tight seal.

10

20

30

In operation, the liner setting tool is assembled at the surface, as described above, and a glass cloth saturated with a resinous material may be wrapped around the corrugated tube to form the liner. The assembly is lowered into the well at the location at which the liner is to be set. A liquid, such as oil, is then pumped under pressure down the well tubing and flows through the passageway 29 provided in polished rod 31, through ports 32 and into cylinder 33 connected to the upper end of the shoulder 16. Upon the application of fluid pressure to the cylinder, the piston 34 secured to polished rod 31 moves upwardly in cylinder 33. As shown, rod 36 connects polished rod 31 and shaft 18 upon which is mounted the first-stage expanding die 17. When the piston 34 moves upwardly through the cylinder 33 the expanding die 17 and the secondstage die 22 are drawn upwardly into the corrugated liner 14 and "iron out" the corrugations in the liner, so that the expanded liner may contact the inside wall of the casing in which it is being installed. Positioned on the shaft below the expanding member 24 is a constant force spring member 37 which is employed to urge the expanding member against the expanding arms 22 with a substantially constant force. The force exerted against the arm members being substantially constant, the force transmitted through the arm members to the liner and to the casing will be substantially constant so that either sticking of the tool in the casing or rupture of the casing is precluded. Of course, the force provided by the spring member is preselected so that the frictional

20

forces between the tool and the liner and the pressure exerted against the casing are maintained at predetermined safe levels. The constant force spring member assures that the contact pressure between the liner forming portion 23 of the arms 22 is great enough to provide the desired deformation of the casing, while preventing damage to the casing or to the tool.

The constant force spring member 37 is slidably mounted on the shaft 18 and held between the expanding element 24 and a cylindrical lower shoulder member 38 forming a portion of a differential screw element 39 which transmits the loading on spring member 37 to shaft member 18. The differential screw element comprises shaft member 18 on the outside of which are cut male threads 18a, the lower shoulder member 38 provided with female threads 38a and thimble member 41 provided with threads 41a and 41b on the outside and the inside, respectively, to engage with threads on the shaft and the shoulder. The two sets of threads are coarse, such as square, modified square, or Acme threads, to withstand very high loads and differ in pitch so that shoulder 38 is moved upwardly on the shaft 18 when the shaft is revolved relative to thimble 41. The shoulder 38 is secured to the shaft 18 by splines 45 so that it can slide longitudinally, but it is not free to rotate on the shaft. Fixedly attached to the lower end of the thimble is a friction member, such as bow springs 42, a hydraulically actuated friction pad, or other such device for frictionally engaging with the inside wall of the conduit to secure the thimble against rotation with respect to the shaft. Preferably, the direction of the shoulder member threads 38a is the same as that of the shaft threads 18a, e.g. righthand threads, and the pitch, or lead, of threads 18a is slightly greater than that of threads 38a, with the pitch ratio being close to unity. In this manner, clock-wise revolution of the shaft relative to the thimble causes shoulder member 38 to advance upward slightly and a compression load is exerted upwardly on spring element 37 to cause buckling. For example, one satisfactory differential screw was made up using five and one-half threads/inch square threads on a shaft approximately 1.7-inch outside diameter and five and threequarters threads/inch square threads on a shoulder approximately 2.5-inches inside diameter.

Constant force spring element 37 comprises column element 45, advantageously consisting of a plurality of elongated columns disposed around shaft 18. Upper bearing plate member 44 is in contact with the upper ends of the columns and is slidably positioned on shaft 18 to transmit the force of the spring longitudinally against the bottom end of expander member 24. Lower bearing plate member 46 contacts the lower ends of the columns and is moved upwardly along the shaft by longitudinal movement of lower shoulder 38 as a result of revolving differential screw element 39. Grooves 47 are provided in each of the bearing plates, to form an upper race and a lower race, into which the ends of the columns are inserted. These grooves may be shaped to conform with the shape of the column ends if desired. A cover 48 may be employed to exclude foreign matter from the spring mechanism and to protect the spring.

10

20

30

A means for limiting the deflection of the columns is required. Although the column element functions in a buckled condition, application of excessive compressive load thereto would cause total failure or rupture of the columns. Therefore, a pair of stops 49 and 49a are provided for this purpose. As shown, the stops are rigidly connected to the bearing plates, and, in effect comprise upper and lower limiting sleeves positioned on the shaft to slide longitudinally thereon. The ends of the stops may move toward, or away from, each other as the load on the spring member varies. Lower sleeve 49a is prevented from moving down by lower shoulder 38 connected to the shaft 18. However, the spacing between the ends is such as to limit the longitudinal travel of the bearing plate members as they move together to prevent permanent deformation of the column element 43. Various alternative means for preventing damage to the column element may also be employed. For example, pins or rings mounted on the shaft may serve as stops, or the cover 48 provided with suitable connections may be employed for this purpose to limit longitudinal and/or lateral deflection of columns.

The columns of the column element 43 may be arranged around the shaft 18, which as shown here forms a portion of the body of the spring device, with ends of the columns fitted in the races 47. The columns may be

fitted closely together as shown, or may be spaced around the race, with separators used between them to maintain the desired spacing. The number of columns employed will depend upon column characteristics and the materials of construction. For example, the slenderness ratio of the column may be varied widely, and the column ends may be round, flat, fixed or hinged. The preferred construction is a thin, slender column with rounded ends, free to move within the races shaped to the curvature of the column ends. Materials which may be satisfactorily employed for the columns are carbon and low alloy steels, chromium and nickel-chromium stainless steels, various copper base alloys, such as phosphor bronze, beryllium copper, the high nickel alloys and other similar materials providing satisfactory mechanical properties. Typically, the individual columns are of long rectangular cross-section, with the width being greater than the thickness, and arranged so that the wider face of the columns is normal to the diameter of the shaft. Thus, with sufficient compression loading, the columns buckle, and bend about the axis having the least moment of inertia, e.g., outwardly away from the shaft lo.

For example, a group of columns 0.167-inch thick by 0.438-inch wide by 10.626-inches long, with the ends rounded, were fabricated from A.I.S.I 4340 steel, quenched and drawn at 575°F. Each column was found to require a 20 critical compression loading of 450 pounds in order to buckle the column. After buckling, the columns were found to have a very flat spring characteristic, as shown in Figure 3, wherein  $P_{c}$  is the critical buckling load and point C represents the load and deflection at which the stress in the extreme fibers of the column exceed the yield point of the material. Theoretically, the shape of this spring characteristic curve is described by curve OA'ABC. Actually, this curve is described by OABC due to friction in the system. Points A and B represent typical working limits, which, of course, may be varied according to the application for which the spring is designed. For example, where a large number of flexing cycles are not anticipated, a working stress just below the 30 yield point may be used, while with a great number of flexures, the working stress may be held to less than the endurance limit of the material of construction. In the above-mentioned tests, the lateral deflection was limited to

spproximately one inch, at which the longitudinal deflection was approximately: 0.225 inches. From zero deflection to the maximum deflection, the 450-pound loading was found to be substantially constant.

In another test a spring device was built, as shown, employing 20 columns, each having a critical buckling load of 1250 pounds. The lateral deflection was limited between 0 and about 1.00 inches by appropriately positioning the stops. Upon compressional loading, the spring element buckled at substantially 25,000 pounds and from a longitudinal deflection of 0.04 inches (buckling) to about 0.15 inches the load remained substantially at 25,000 pounds.

10

Of course, in designing a spring element as above it is advantageous to obtain the greatest possible value of longitudinal deflection for specified values of lateral deflection and critical buckling load, while maintaining the stress level in the columns at a safe level. The preferred columns, therefore, are laminated, as shown in Figures 1B and 2, with multiple flat members making up each column.

In the operation of the above expanding tool for setting a liner in well casing, the made-up tool is lowered into the well as mentioned above, with the arms 22 in the retracted position. When the tool is at the desired level, the well tubing is revolved. The friction member 42 engages with the wall of the casing and prevents thimble 41 from revolving. With several revolutions of the tubing, lower shoulder 38 is moved upwardly by differential screw 39 to buckle spring element 37 which has a predetermined critical buckling load. This load is transmitted upwardly against the lower end of expander 24, and its tapered surface is engaged with the tapered surface on the inside of the arms 22 to urge the arms outwardly with a substantially constant force proportional to the critical buckling load of the spring element. Subsequently, the expanding tool is passed through the liner to expand it in the casing in the manner described hereinbefore.

The foregoing description of a preferred embodiment of my invention has been given for the purpose of exemplification. It will be understood that various modifications in the details of construction will become apparent to

the artisan from the description, and, as such, these fall within the spirit and scope of my invention.

#### I CLAIM:

- 1. A device for expanding a metallic liner inside a conduit which device comprises a shaft element, an expanding die member attached to said shaft element, said die member comprising a movable liner-forming member positioned on said shaft and being radially movable in respect thereof to contact said liner, an expander member slidably positioned on said shaft between said shaft and said die member to move said liner-forming member from said shaft, and a constant force spring member positioned on said shaft to contact said expander member and to maintain said expander member against said liner-forming member, whereby said liner-forming member is urged against said liner by a substantially constant force.
  - 2. In a device for installing an expanded metallic liner in a conduit wherein an expanding die is moved through a liner positioned in said conduit to expand said liner: a cylindrical shaft element, an expanding die member attached to said shaft, said die member comprising a plurality of arm members disposed around said shaft and being pivotable outwardly therefrom to contact said liner, a cone member slidably positioned on said shaft between said shaft and said arm members to urge said arm members outwardly from said shaft, and a constant force spring member positioned on said shaft to contact said cone member and to maintain said cone member in contact with said arm members, whereby said arm members are urged outwardly by a substantially constant force.
  - 3. The device of Claim 2 wherein said constant force spring member comprises a plurality of columns disposed around said shaft, a first bearing plate member and a second bearing plate member, each of said bearing plate members contacting opposite ends of said columns, at least one of said bearing plate members being movably positioned on said shaft and being in contact with said come member, stop means connected to said shaft to limit the axial travel of said movable bearing plate member along said shaft, and compression means for maintaining a lateral deflection in said columns.

- 1 4. The device of Claim 3 wherein said compression means comprises
  2 a differential screw connecting said spring member and said shaft.
- 5. The device of Claim 3 wherein said stop means comprises a

  sleeve-like element connected to said movable bearing plate member and

  slidably positioned on said shaft and a member connected to said shaft to

  limit the travel of said sleeve-like element.
- 6. The device of Claim 3 wherein said columns have a rectangular cross-section, the width being greater than the thickness, and having the wider face normal to the diameter of said shaft.
  - 7. A device for installing an expanded metallic liner in a conduit which comprises a cylindrical shaft element; an expanding die member mounted on said shaft, said die member comprising a plurality of arm members disposed circumferentially around the outside of said shaft and being pivotable outwardly therefrom to contact the liner; a conical expanding member slidably positioned on said shaft between said shaft and said arm members to urge said arm members outwardly from said shaft; a plurality of slender columns, each having a long rectangular cross-section and disposed circumferentially about said shaft; an upper bearing plate member and a lower bearing plate member, each slidably positioned on said shaft and contacting opposite ends of said columns; limiting sleeves attached to each of said bearing plate members and slidably positioned on said shaft; a shoulder member on said shaft; a differential screw element connecting said shoulder and said shaft to apply a buckling load to said columns; said shoulder being engageable with the limiting sleeve connected to said lower bearing plate member, whereby the axial travel of said bearing plate members is limited; said column members transmitting their buckling load to said arm members to urge said arm members outwardly with a substantially constant force.

A

1

2

3

5

6

· 7

9

10 11

12 13

14

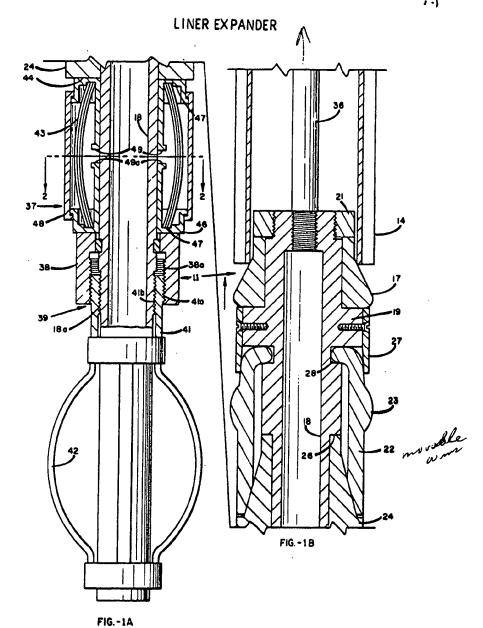
15

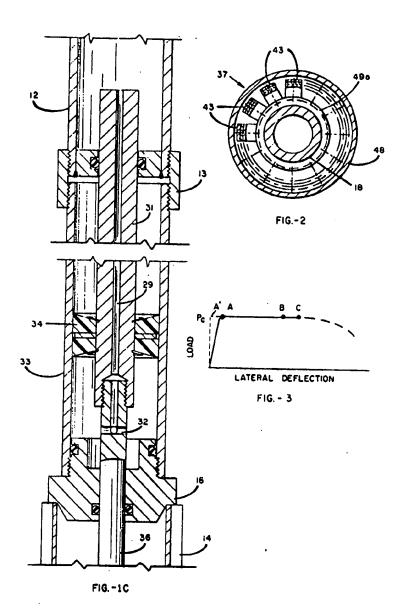
16

. 17 18

\*

11.5 1.5

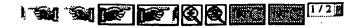




Sorry, the requested images for patent number 736288 are unavailable.

O Her Majesty the Queen in Right of Canada, 1999

Canada http://strategis.ic.gc.ca



T CIATE

A. A dovice for expiriting a metallic liner inside a conduct which device comprises a staff alment, on expending the moder attended to said shaft closure, stid die number comprising a movelle liner-forming number positioned on said shaft and being patially sovelle in respect thereof to contact said liner, as expender moster alidably positioned on said shaft between said shaft and suid die number to move said liner-forming number from said shaft, and a constant farms spring number positioned on said shaft to contact said supposes symbor and to maintain shid expension sustains and liner-forming senter; starrily said liner-forming number is urged against

2. In a device for installing an expended setablic liner in a conduct wherein an expending die is moved through a liner positional in said stockets to expend said liner: a cylindrical shaft almost, an expending dip number attached to said shaft, said the reptor comprising a plurality of are numbers disposed around said shaft and being pivotable intearily therefore to contact said liner, a come number alidably positioned on said shaft between said shaft and said arm numbers to verp said arm numbers consertly frue said shaft, and a constant force spring number positioned on said staffs to contact said come number and to mintain said come number in contact with said are numbers, whereby said age tembers are urged outwardly by a substantially comentant force,

3. For device of Claim 2 wherein shid counters from spring nowber comprises a plumility of columns disposed account said shaft, a first boaring plate sentur and a second bearing plate somber, each of said bearing plate members contacting opposite come of said columns, at least one of said learing plate numbers being receiving presistents on said what's und being in contact with said come number, stop means compared to said start to limit the axial travel of said nowhile bearing plate number along said start, and compression means for maintaining a lateral definition in said columns.

10



**建**态中,于**对对对**企业的可以在中国企业的企业的企业中的企业中的



- . A. The device of Claim 3 wherein self compression group comprises a differential survey equatoring and apring ansers and self shaft.
- 5. The device of CLAIR 3 wherein anid stop means comprises a alsow-like element commerced to said movelle bearing place number and CLIMANIP positioned on said short and a surface communied to said shaft to limit the travel of said alsow-like element.
- 6. The device of thate 3 whereis said column have a metrapular group-section, the width being greater must be thicknow, and tening the wider free second to the dismotor of said shaft.
- 7. A device for installing on expended soballis liner in a contact which comprises a cylindrical shaft classical on acquaiting dic against sounted On maid shall, said the senter comprising a plantity of are sombare disposed sfarentially around the outside of said shaft and budge pluotable cetsuchly therefrom to soutest the liner; a scaled argunding master slidebly positioned on said short between said short and maid are employed to unpersaid bers outsantly from suid shaft; a plurality of elemen columns, cash baving a long reutangular orces-section and disposed stranspantially shout suid chaft; an upper bearing plate number and a lower bearing plate suster, each slidsly positioned on said shaft and contacting opposite onds of said m; limiting slaures ubtended to each of said bearing plate members and alidably positioned an said statt; a aboulder number on said shaft; a differential sows showed connecting will shoulder and said sho(s to apply sting look to saft enimms said thoulest being ourspeaks with the limiting sizers connected to each lower bearing plate mester, whereby the arial known of said bearing plate members is limited; said column resolute branesitting their buckling look to said are zenbors to urgs said and grobers enterrolly with a substantially constant force.

A

17

11





#### LINE EXPLICES

This investion exists to a constant force spring deries, and sore particularly, to a device for expending a establic liner wherein an ampaning dis is urged against the liure by a constant force agring device.

Deprisotors, a matriot and apparetus have been developed for installing up requests socialito liner to an oil well or other conduit. Explosity, a consupted about liner is famoried in a conduct which is in be hired, the greatest parighosal-dissortion of the liner being slightly less then the leader disenter of the emphasis. In expending took is passed the liner placed in the southit, and a first-close expanding the somes a gross plantic deformation of the liner, which is experied outseedly vides on shiltional finer defermation of the limes to provide a m some finished surface on the inside of the liner and to secure some complete contact between the contact and the liner. In a typical design of this type expending tool, the frictional drag of the first-stage die supplies the expending Impo for the second-stage dies, which expending force is a kireat function of the strength, or wall thickness, of the conduit is which the liner is being installed. For example, in limity oil well casing, heavy ring may come a very high Erictional Course which results in exce es boding regarded to youth the expender through the liner. The application of the great forces required may result in replace of the casing me in breaking the impulling tool. In testamon whose the internal that of the combut is somewhat ions than their articipated, the results can some the tool to become stock in the casing, or otherwise age to the enging and the tool. In other dealgra, such as there a quithlever againg arrangement is employed in accommission of \$6 the secondstigs dis, various difficulties are encountered in obtaining a spring sion having the desired strength is continution with the other spring characteristics, and with the tool dragging against the inside will of the db after bring passed through the liner.

. 'A



PROPERTY OF THE PROPERTY OF TH



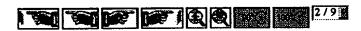
Since tooks of the type mentioned above of her are employed in welldeep in the ground, it is highly preferable that a took he used which under no circumstances will become stack in the well or utuse demage to the well. Any such trouble occurring in a well one remail in considerable loss in time and great expense in making repairs.

As abject of the present invention is a Sovice for applying a concreat force to an expending die or other similar expension so that a presciented maximum force to anarted against a verb piece. Inother object is an improved expending tool for installing metallic liners in a conduct, which expending tool can apply so greater them a predictantised force to the liner being installed in the conduct. Still another object of the invention is an economical and enally fabricated constant force spring device. A further object to a rugged, ansy-to-coursele expending tool captaying such a spring device. These and other objects of the invention will become apparent by reference to the following description of the invention.

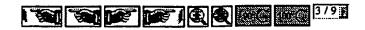
In accordance with the present invention there is provided a constrait force spring device which comprises a body member, an elongated column element adjacent said body member, bearing plate members contexting the two spin of said column at least one of said bearing plate surdows being longituationally moveles in respect of the other and stop memor or said body member to limit the deflection of said solumn element to provent personner deformating of said solumn element upon the application of a compressive load thereto. In one admittant of the invention, the foregoing constant force spring device is anglayed in a tool for expending a setallic liner inside a constant, mill complete force spring device being periblomed on acid tool to may as expending the number against the liner being installed in the combact by a substantially constant force.

My invention will be better understood by reference to the following description and the accompanying drawings wherein:

Figure 1A, 15 and 1C, table together, convilute a partial sectional view of a preferred embodiment of a liner expending tool according to the present investion; and



Page 1 of 1



#### 736288

Figure 2 is a sectional view of the apparatos of Figure 1A taken at the 2.2s and

Figure ) is a typical plot of applied lock versus Delication for the constant force spring device of the Lavention.

Referring to the drawings, Figure 14 is the lotton portion of a liner expending tool for one in installing a motallic liner in a will, while Figure 13 Libertrator the middle section of such a tool and Figure 10 reprements the upper sertion of the tool. The organizing tool il is attached to standard well tabing 18 by compling 13 and, typically, may be lowered from the surface through a well easing (not shown) to a point in the nuring at which it is secured to install a metallic liner. Before inserting the book into the well, an elongated vertically corregated liner in fabricated from mild steel, or ether suitable entirable meterial, is placed on the tool. The correspond liner is secured in position by sentant at its upper end with a cylindrical shoulder number 16 and, st the lower and by contact with a first-stage expansing die 17 in the form of a trumosted circular cone stdah serves as a firsteding 41s in the sevener barrinester described. The expanding die is fixedly absended to a controlly located, elongated cylindrical bollow shaft ld which forms a portion of the body of the tool. As shown, the expending Sie 17 is half in place between a lower shoulder 19 and coller 21 threaded onto the short. A plurality or moveble eros 89, preserably provided with outserelly sularged portions 25 sear the top; who disposed in the form of a syllndar around shaft 18. The unlarged purbloss of the some 23 upon being soved outvarily emises the liner to perfore the final step of expending the marageted himor into a substantially syliminical shape. The are combers IX tre pivotally etteched to the sheft so me to be movehlo outwarfly from the sheft by a tapered expending member 26 slikebly positioned on the shuft to serve as a second-stage expender. The explane of the meshed th, as shown, moves spreadly along the shart to sugage with the arms and more them outwardly. Advantageously, the inside surfaces of the area 82 and the outside earface of outside member 25 form sating sentiums, typically cotegonal is shape. The expension of the arm members is comiralised by the position of the member 24 rhich moves upwardly



SOMETHING THE PROPERTY OF THE PARTY OF THE P

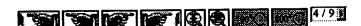


#### ¥36288

entil) it contents absolder 26 provided on the chaft. As member 24 moves in a documently direction area 22 feld invertily towers the sheft. The expending same 22 are held to place as the sheft by collect 27 and currelar grooms 20 provided on the sheft.

The expending tool, comprising the first-stage die and the sentalstage die is dress through the limit to expend it is place in the casing. Du first-stage die provides a gross deformation of the liner so that it is expended convertly against the wall of the sening. The second-stage die then passes through the liner and performs the final expension to exouth the inner surface of the liner and its provide more even contact between the liner and the wall of the centur and effect a finid-light scal-

In operation, the liner setting tool is assembled at the surface, so described shows, and a glass cloth saturated with a restance material may be excepted around the corrugated take to form the liner. The assembly is lovered into the well at the investion st which the liner is to be set. A liquid, such so oil, is then pusped unfer pressure down the sell taking and flows through number 29 provided he golished roi 51, through parts 52 and into epilader 35 commetted to the upper and of the shoulder 16. Upon the application of finid pressure to the cylinder, the piston 34 second to polished red 31 moves upwertly in spinner 35. As shows, rot 36 cornerts polithed rot 31 and shaft 18 spon shigh is mounted the first-stage expending die 17. When the piston % neves upwardly through the sylinder 35 the expanding die 17 and the secondstage die 22 are draws upwardly into the corrugated liner 18 and "Iron out" the corregations in the liner, so that the expended liner may content the family well of the casing in which it is being installed. Positioned to the shaft below the expending seater 26 is a constant torce spring number 27 which is employed to mys the experding number against the exploiting arms 22 with a substantially sometant force. The force exerted against the amb members being substantially sometant, the force transmitted through the arm masters to the lists and to the during will be substantially constant on that either sticking of the tool is the casing or repture of the casing is precluded. Or course, con provided by the spring master is preselected so that the frictional



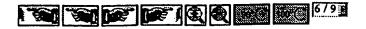
ALL NATIONAL CONTROLLES, VOLTANDAMON MAINTENANT CONTROLLS - CONTROLLS CONTROLLS - L'A



forces between the tool and the liner and the presence emerted agrine the oneing are maintained at predeferringed safe levels. The commission force spring
maker easures that the contact presence between the liner forming springs of
the arms 22 is great except to provide the desired safermention of the osciing, while preventing desires to the easing or to the tool.

The equators force spring season 77 is alignity sourced on the about 18 and hald between the expending alongst 29 and a cylindrical lower aboutour season 39 forcing a parties of a differential server alonest 39 which transmits the lower season of the matter 16 at the outride of which are not rate transfe alongst comprises shaft master 16 at the outride of which are not rate transfe life, the lower shoulder master 39 provided with female threads 35 and thinkle number 31 provided with threads and all on the origins and the lands, respectively, to sepage with threads on the shaft and the shoulder. The two codes of threads are source, such as square, notified square, or force threads, to vithertand very high loads and differ in pitch so that shoulder 35 is seven upserfly on the shaft 15 when the shaft is revolved relative to thinkle \$1. The shoulder 36 is second to the shaft if by splines \$5 so that it can alide longitudinally, but it is not tree to robate on the shaft. Finally atmobed to the lower and of the thinkle is a friction scaler, such as how aprings \$2, a hydrallically estuated friction pas, or other such devices for frictionally mastering with the inside wall of the shaft. Frederickly, the direction of the choulder transfer, such the patient. Preferably, the direction of the choulder transfer with respect to the shaft. Frederickly, the direction of the choulder master threads 35s, with the pitch, or lead, of threads 15s as slightly greater them thank or threads 35s, with the pitch, or lead, of threads 15s as slightly greater them therefore the service upwerd alightly and a compression load is smerted upwerly on apring element 37 to comet backling. For example, one existencery differential acres was mate up using five and one-half threads/inch equare threads upwerly threads on a obset approximately 1.7-inch outside dissector and five and increase.

5/9



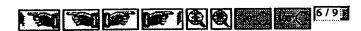
Dissilat force spring element 31 comprises unions also by, sometageously committing of a plurality of alongsied column dispoted around short 18. Upper bearing plate number th is in contact with the apper unds of the administed is elikely positioned on shart 18 to treatment the force of the spring longitudinally against the bottom and of expender sealer. Sh. Lower bearing plate number 66 contacts the lower main of the columns and 18 moved quantity along the seart by leadibelinal movement of lower smoulder 50 on a result of revalding differential survey alamost 39. Grooves 37 are provided in seals of the bearing plates, to form on upper case and a lower case, into which the cents of the column are inserted. These grooves may be chaped to confurn with the shape of the column unds 17 section. A cover 48 may be employed to anolide foreign setter from the spring mechanics and to protect the spring.

A needs for limiting the deflection of the columns to required.

Although the column element furctions in a bushled condition, application of grossalve acquirestive load thereto would cause total feiture or repture of the columns. Therefore, a pair of stope by and itse are provided for this purpose. As shown, the stope are rigidly commerced to the bearing plates, and, in affect comprise apper and lower limiting clasves positioned on the shaft to alide longitudinally thereon. The under of the stope may nove toward, or easy from, each other me the load on the squing number varies. Lover slaves his is prevented from nowing form by loads shoulder 35 nonmerced to the chart 15. Revers, the spacing between the cash is much as to limit the longitudinal travel of the bearing plate numbers as they move together to prevent personnel deformation of the column almosts 55. Various alternative manns for preventing damage to the column almosts by. Various alternative manns for preventing samage to the column almosts may also be employed. For example, plate or rings someted on the other may surve as stope, or the cover 48 provided with satisfully connectations may be employed for this purpose to limit longitudical and for lateral deflection of columns.

The columns of the column element \$5 may be arranged eround the grant 16, which as shown here forces a portion of the body of the spring flavour, with code of the columns fitted in the reces \$7. The solumns may be

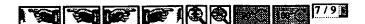
- 6 -

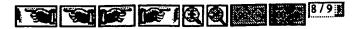




ritted closely bogs her as shows, or may be spared around the race, with separators used botsoon them to meistain the desired sparing. The rember of construction. For example, the elementary ratio of the column may be varied withly, see the column may be round, flat, fluxe or binged. The preferred construction is a thin, element column with tousded ands, free to now within the races shaped to the soresiste of the column code. Materials which may be satisfactorially employed for the column are or column and loss alloy cheels, chronius and michal-shronius stainless steels, various aspect bear allique, such as passaphor bronco, beryllius sopper, the high middle alloys and other minitar anterials providing satisfactory mechanical properties. Typically, the individual columns are or long rectamplar cross-cention, with the midth being greater than the latchment, and arranged so that the wider face of the university anomals to the dimentar of the short. Thus, with surfaciant compression loading, the columns backle, and hand about the arise having the loars second of inartia, e.g., outstartly may from the short 15.

For example, a group of columns 0.167-inch thick by 0.438-inch wife by 10.625-inches long, with the ands rouwled, were februarted from \$.1.8-I 43to steel, quenched and draws at 575°F. Duch column was found to require a critical suspension loading of 450 pounds in order to bunkle the addust. . After buniling, the columns were found to have a very flot spring characteristio, as shown in Figure J, thereis Po is the critical backing load and point exter the load and deflection at which the stress in the extress fibers m exceed the yield yount of the untertal. Theoretically, the shape of this spring obstactaristic ourse is described by entre OA'ABO. Arinally, Unis curve is described by OkiC due to friction in the system. Potenta A and B represent typical straing limits, which, of course, may be varied according to the appliantion for which the spring to designed. For example, where a l ther of flexing epulse are not moticipated, a working atress just below the 30 yield point may be used, while with a great number of flexures, the working see may be held to less than the enforcement limit of the seterial of so tion. In the above-mentioned tests, the lateral deriection was limited to





approximately one just, at which the longitudinal defloration was approximately 0.225 inches. From more deflection to the section deflection, the \$50-pound loading was found to be substantially constant.

In emother test a spring device was built, as shown, employing 50 columns, each having a critical buckling load of 1250 possès. The interal deficients was limited between 0 and about 1.00 inches by empropriately positioning the stope. Once compressional loading, the spring element buckled of embetantially 25,000 possès and from a longitudinal defication of 0.00 inches (buckling) to about 0.15 inches the load remained substantially at 25,000

Of course, is dorigated a spring element as above it in elementageous to obtain the greatest possible value of longitudinal defination for specified values of laboral deflection and critical bushing load, while unintending the atrees level in the columns at a safe lavel. The preferred columns, therefore, are laminated, as about in Figures 18 and 2, with multiple flat anchors units to seek column.

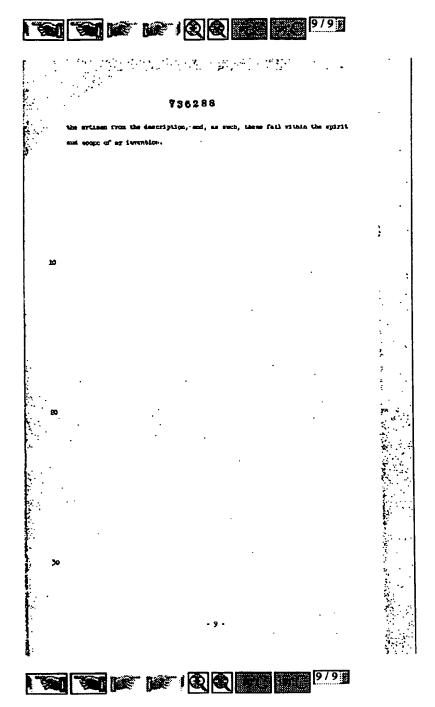
In the operation of the above expending tool for setting a liner in well encises, the mede-up tool is lovered into the sell as sectional above, with the area 22 in the retreated position. Then the tool is at the desired level, the well taking is revolved. The friction number by capages with the wall of the entire and prevents thinkle hi from revolving. Eith several revolvings of the taking, lower absolder 16 is nowed appeared by differential server by to bushle spring almost 37 which has a predefending writinal buckling loss. This lost is transmitted assembly against the lower and of expender 16, and its tapered surface is engaged with the tapered surface on the Lands of the error 22 to args the large outwardly with a substantially constant force proportional to the critical buckling loss of the spring almost. Subsequently, the expending tool is passed through the liner to expend 10 to the casing in the means described hereisles over.

The foregring description of a preferred embalianst of my invention has been given for the purpose of examplification. It will be understood that various madifications in the detects of association will become apparent to

- 8 -

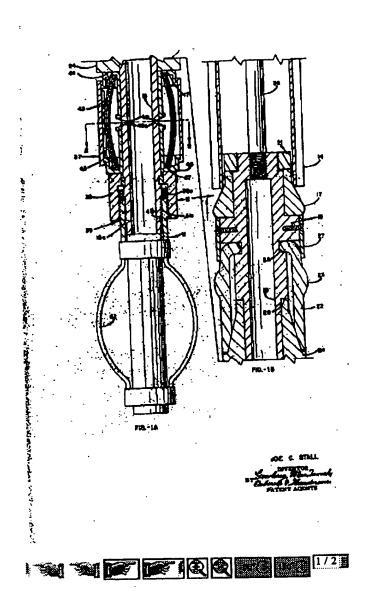
THE RESIDENCE OF THE PROPERTY OF THE PROPERTY

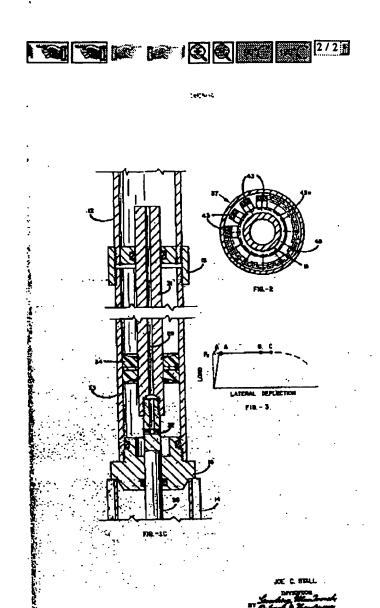
8/9 **8 8 9 8 9 8** 

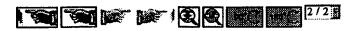




CIRMIS







# This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

## **BEST AVAILABLE IMAGES**

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

BLACK BORDERS	
☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES	
☐ FADED TEXT OR DRAWING	
☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING	
☐ SKEWED/SLANTED IMAGES	
☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS	
☐ GRAY SCALE DOCUMENTS	
☐ LINES OR MARKS ON ORIGINAL DOCUMENT	
☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY	
□ other.	

## IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.